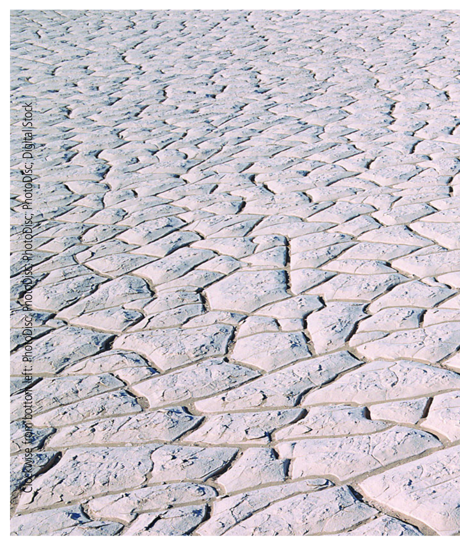
Where Do We Stand?

How healthy are the earth's ecosystems? Will they continue to provide the food, water, shelter, and other necessities on which all life depends? These pressing questions have been receiving attention from two international collaborations: The Pilot Analysis of Global Ecosystems (PAGE) was completed in late 2000 and detailed in *World Resources 2000–2001*, the biennial report of the World Resources Institute (WRI), and the upcoming Millennium Ecosystem Assessment (MEA) is due for completion in 2005.

The degradation of ecosystems is literally ancient history. Desertification—an enduring ecosystem degradation—gets much of the blame for the decline of ancient civilizations in the Middle East. More recently, the severe soil erosion of the Dust Bowl in the U.S. Great Plains during the 1930s started with unsustainable farming practices and was exacerbated by drought. In total, according to a 2000 report by the United Nations Environment Programme (UNEP) titled *An Assessment of Risks and Threats to Human Health Associated with the Degradation of Ecosystems*, desertification is now damaging 30% of irrigated areas, 47% of rainfed land, and 73% of rangelands.

Other examples of broad ecosystem degradation include the hypoxic "dead zones" in the Gulf of Mexico and other waters around the world, the disastrous decline of Black Sea fisheries due to the introduction of exotic species, and intensified flooding in Bangladesh and Central America caused partly by deforestation. These and other such alterations reflect global-scale changes caused by human activities, particularly climate change and stratospheric ozone depletion.

Ecosystem assessments stand traditional environmental monitoring on its head by examining an entire ecosystem, such as a watershed, mountain range, or coastline, rather than, say, a tract of land or an industrial sector. No longer, says David Rapport, a professor in the School of Rural Planning and Development at the



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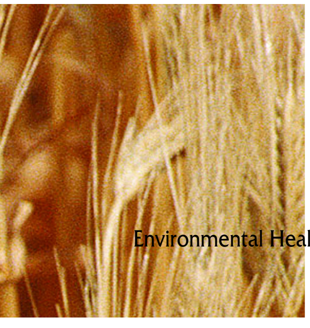
Global Ecosystem Assessments

Ask the Big Question



University of Guelph in Ontario, Canada, is it sufficient to address problems of agriculture, biodiversity, or fresh water in isolation, when the entire ecologic fabric is getting ever more threadbare. “Healthy organisms can only exist in a healthy ecosystem,” Rapport says. “It’s becoming dysfunctional to the point that the basic needs for life—fertility of the soil, regeneration of fisheries, arable land productivity, fresh water—all these fundamental services, nature’s gifts, are being eroded.”

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The PAGE is the most ambitious effort at worldwide ecosystem assessment to date. Coordinated by the WRI, the PAGE got help from 18 players, including the World Bank, several United Nations agencies, and organizations concerned with food and the environment. The PAGE was designed to serve as a pilot project for the MEA, which will cover an even more ambitious scope.

The MEA will document the condition of ecosystems past, present, and future. Rather than prescribe changes for policy makers or dictate which problems are most pressing, it will write scenarios to guide the actions of industry, government, and international agencies, says Robert Watson, chief scientist and director of the World Bank’s Environmentally and Socially Sustainable Development Network, who is also cochair of the MEA’s board of directors. These scenarios will paint very broad pictures of how the world’s ecosystems could change based on certain uncontrollable variables. They can therefore guide the actions of industry, government, and international agencies within their own spheres.

Scenarios are a departure from the traditional approach to ecosystem management, points out Stephen R. Carpenter, a professor of limnology at the University of Wisconsin at Madison, who will cochair the MEA scenarios group. He adds, “The classic approach to decision making is to make a prediction and act on the probability [of the various outcomes]. The problem with projecting the world’s environment is that we don’t know the probability distribution, and a very wide range of things can happen.”

Ecosystem Assessment: What Purpose Does It Serve?

According to the description of the PAGE in the 2000–2001 WRI report, ecosystem assessments have six main characteristics. They broadly evaluate how humans affect the functioning and productivity of ecosystems. They focus on an entire ecosystem rather than traditional jurisdictions or sectors. They take a long view of ecological health. They examine the entire productive potential of an ecosystem. They stress relationships rather than individual sectors or outputs. And finally, they accept people as part of ecosystems.

The cross-sectoral approach is key, says Ashbindu Singh, a UNEP researcher who cowrote *An Assessment of Risks and Threats*. He says environmental monitoring used to focus more on sectors such as forests or water. In contrast, the ecosystem approach integrates all aspects of the ecosystem, and by definition considers human actions. “People are the biggest drivers of change,” Singh says, “and need to be included in the assessment.”

A prime motivation for the MEA, says Carpenter, is three global treaties on wetlands, biodiversity, and desertification that require the scientific community to provide a coherent information base that the convention secretariats can use to make decisions. “There was a recognition within the scientific and policy communities that these [treaties] had pretty strongly overlapping information needs,” he says. “Given that the community of scientists that can do this globally is pretty small and the cost is pretty large, why not do one scientific effort?”

Another reason to look globally is the growing intensity of human use of the biosphere. According to Walter Reid, a former official of the WRI who was acting science director for the MEA, by 2020 world demand for rice, maize, and wheat will grow by 40%, and livestock production by 60%. By 2025, humans are expected to use 70% of the freshwater runoff from snow- and rainfall. “These growing demands for ecosystem goods and services can no longer be met by tapping unexploited resources,” Reid wrote in the Spring 2000 edition of *Issues in Science and Technology*. “A nation can increase food supply by converting a forest to agriculture, but in so doing decreases the supply of goods that may be of equal or greater importance, such as clean water, timber, biodiversity, or flood control.”

Carpenter also believes that from a decision-making standpoint perhaps the biggest mistake that could be made is leaving out important possibilities. For example, he says, if the Ross Ice Shelf in Antarctica breaks loose from the ocean floor, the sea level could rise by 10 meters virtually overnight. Thus, he says, sudden changes will become the basis for some MEA scenarios.

The scenarios will rest on data from the physical sciences, such as studies of global warming. Social and political conditions, Carpenter says, will play a key role in future conditions. “Will the world by 2050 be largely globalized, with . . . a very flexible international exchange of goods and services?” he asks. “Or will there be vast areas where democracy and the rule of law fail and the open market cannot function? Those two worlds have hugely different implications for the way ecosystems and the environment will operate.” Because the probability of any one scenario coming to pass is uncontrollable and unpredictable, Carpenter says, the group will try to forecast their ecologic impact without necessarily evaluating their likelihood as starting points.

However, the MEA’s data may help other organizations set priorities, says Kenneth Kassem, a conservation specialist at the World Wildlife Fund who also worked on the PAGE. Because the MEA considers biodiversity an essential benefit of healthy ecosystems, its results will help groups refine their evaluations of conservation status around the world.

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Ecosystem assessments elucidate a lot of interesting relationships. Water is the basis of several surprising interactions. For example, a recent study published in the 15 May 2001 online version of *Proceedings of the National Academy of Sciences of the USA* by Daniel Rosenfeld, a professor in the department of atmospheric science at the Hebrew University of Jerusalem in Israel, linked dust from the Sahara Desert with reduced rainfall. Although raindrops must condense on dust or some other nucleus, the desert dust produced too much of a good thing; many water droplets formed in the atmosphere, but they were too small to drop out as rain. If confirmed, such a destructive feedback loop could intensify desertification. Drought and overgrazing would cause dust and then more drought, thus damaging the rangeland further and causing yet more desertification.

Consideration of ecosystem effects could help forecast the consequences of human actions and prevent the kind of surprises that followed a World Health Organization malaria control program that sprayed the pesticide dieldrin in Borneo in the 1950s. According to Jonathan Patz, who is director of the Program on Health Effects of Global Environmental Change at the Johns Hopkins Bloomberg School of Public Health, the mosquito population declined as desired, but other, unexpected problems took their place, including thatched roofs that began falling in and a major typhus epidemic. Lizards died from eating poisoned insects mosquitoes, and cats died from eating the poisoned lizards, allowing rats to run rampant, covered with fleas that carried typhus. The insecticide also killed wasps that formerly kept the caterpillar population in check, and the caterpillars ate the thatched roofs, which then fell in. “By trying to do a directed treatment, they ended up with problems worse than they started with,” Patz says. The story, he says, is a “classic example of how everything is interrelated.”

One exceedingly complex issue that ecosystem assessments must try to tackle is carbon storage—the removal of the greenhouse gas carbon dioxide from the atmosphere. About 7.9 billion tons of carbon enters the atmosphere each year from human activities, primarily burning fossil fuels, deforestation, and agriculture. About 2.3 billion tons is dissolved in the ocean or taken up by marine vegetation, so global warming is affected by conditions that alter marine ecosystems, including pollution, siltation, and introduction of exotic species. Terrestrial ecosystems take up another 2.3 billion tons of carbon per year.

Carbon storage brings up countless physical, biologic, and economic issues. For example, fixation of organic nitrogen into inorganic forms that are available to plants, largely through fertilizer production, hastens plant growth—leading to more carbon storage—but also causes excess and unhealthy growth in freshwater and marine environments. Carbon is stored in soil as organic matter that helps soil retain water, a process that is reversed by erosion and desertification, both of which reduce carbon storage. Thus, agricultural and forestry practices are both major determinants of carbon storage: they directly influence the amount of carbon stored in vegetation and indirectly influence soil storage. Ecosystem assessments must try to forecast the effects of other actions that affect carbon storage, such as nutrient management and the use of organic fertilizer and minimum tillage, but the challenge is daunting.

Lessons Learned from the PAGE

The results of the PAGE were neither surprising nor encouraging. “The message was that ecosystems are in a precarious state,” Watson says. “They can be saved, but with business as usual, we’re going in a direction that over the long haul is not going to be able to support the goods and services we require.” Using primarily literature reviews rather than original research, the PAGE painted a grim picture of five ecosystems: agricultural, coastal, freshwater, marine, and forest systems.

Agroecosystems have allowed crop output to double since 1970, but a soaring worldwide demand for food will continue to stress farmlands and rangelands. About two-thirds of agricultural land has been degraded over the past 50 years by erosion, salinization, soil compaction, nutrient depletion, biological degradation, and pollution.

Coastal ecosystems are being harmed by a growing human population—40% of humanity lives within 100 kilometers of a coast. Other harmful factors include increasing use of synthetic chemicals and fertilizers, overfishing, and destruction of fish nurseries. Increases in hypoxia and harmful algal blooms and declines in fish harvests indicate the decreasing health of these ecosystems.

Freshwater systems have been damaged in most parts of the world by agriculture, industry, and urbanization. People already use about half of present river flow, and the percentage is rising. About 20% of freshwater fish species have gone extinct in recent decades, or are threatened or endangered. About half of all wetlands were destroyed during the twentieth century for farming and development. As a result of all these factors, 5 million people die each year from lack of adequate drinking water and good sanitation.

Forest cover has been reduced by 20–50% since preagricultural times and continues to decrease by 0.7% per year. The PAGE attributes forest loss to economic development and population pressures, and found that logging, mining, and road building all expose forests to settlers, hunters, fires, and invasive species. Deforestation can reduce rainfall, because trees return rainwater to the atmosphere as water vapor, which then condenses into rain. Deforestation can also increase runoff, causing flooding and siltation downstream. Deforestation harms biodiversity, reducing the variety of plants and animals available for drug discovery and crop breeding. It also changes insect habitat, resulting in the expansion of vectorborne diseases such as malaria and dengue fever.

Grassland ecosystems cover 31–43% of the planet’s land surface and are home to 17% of the human population. Grasslands

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are under threat from overgrazing, unwise conversion to croplands, and fires used—and often misused—by farmers and ranchers to clear brush.

Although global by nature, the PAGE also has local components (as will the MEA). For example, the PAGE looked at the health of grasslands in Mongolia, an area where for thousands of years nomadic herders have subsisted without causing fatal harm to the ecosystem. By collaborating in rotating animals over shared pastures in prescribed ways, herders were able to secure their country's economy without degrading its ecosystems. New social and economic practices are threatening the rangeland, however. Smaller, more static livestock operations will require fodder crops, but half of Mongolia's limited croplands are already degraded. The change from traditional, collective land tenure to private ownership of land and herds, the PAGE found, "has decreased flexible systems such as rotational grazing and access to shared grazing lands."

The PAGE also examined case studies of promising solutions to ecologic problems. Many of its case studies were small, locally managed projects that were intended to serve people and nature at the same time. A mangrove restoration project in the Caribbean nation of St. Lucia, for example, showed how local input could help preserve these coastal trees, which protect tropical coastlines from erosion and provide nursery habitat for finfish and shellfish. A 63-hectare tract of mangroves was being cut without restriction by local charcoal makers. By the early 1980s, a local nongovernmental organization proposed to include the charcoal makers in managing the mangroves for sustainable use. A new inland tree plantation augmented the wood supply, and the mangroves' health improved with little decline in charcoal output.

People are the biggest drivers of change and need to be included in the assessment.

–Ashbindu Singh, United Nations Environment Programme

Assessing the Assessments

Watson, who formerly directed the Intergovernmental Panel on Climate Change (IPCC), the ongoing United Nations–led effort to document global warming, says that, in an effort to secure wide dissemination and acceptance, the MEA will borrow some of the techniques of the IPCC, whose massive periodic reports are written by a broad range of scientists. The MEA will, for example, be written and reviewed by 1,000–2,000 scientists, assuring wide scientific awareness of the product (the PAGE, by contrast, got almost no publicity). To further ensure acceptance, MEA organizers are talking with environment ministries, industry leaders, and international organizations such as the World Health Organization during the planning phase.

The carbon storage example points to one key hurdle of these assessments: the sheer complexity of global environmental problems. Carpenter says he hopes to deal with that complexity in the MEA without getting bogged down. "I intend to make hard-nosed, pragmatic decisions to keep complexity under control," he says. "You will leave some important things out, but you will actually get something done." For a project as ambitious as the MEA, he adds, "it would be disastrous to wallow in complexity and never develop a product."

William Clark, a professor of international science public policy at Harvard University's Belfer Center for Science and International Affairs, says rushing to judgment on large international scientific efforts such as the MEA is a mistake. After years of study of the effectiveness of similar efforts, he found that even the most influential reports tend to be less influential when considered by themselves. Ecosystem assessments, he says, should be seen as part of a long-term process that will go on to produce future reports and actions. He points to the highly influential IPCC, which has successfully positioned itself as the final authority on climate change but which initially got little notice outside the field.

Clark dismisses the idea that the MEA and future assessments like it will become just another global ecosystem report gathering dust on the shelves of scientists and policy makers. Cynics, of course, wonder whether these reports will really tell us about how to reallocate resources. Will they be dismissed as too ambitious or too complicated? Will they help in the inevitable political and economic battles over development and environment? And will the MEA, like its predecessor the PAGE, disappear from view as soon as it's finished?

Watson acknowledges the possibility of that happening, but says the MEA is determined to make its report count. The goal, he says, is "not to tell us that world ecosystems are falling apart—we know that—but to identify the underlying causes. It's not to have prescriptions, but to demonstrate what different choices will mean to meeting our needs for food, fiber, etc. The onus is on us that it's not just another book showing that we're going to hell in a handbasket."

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–Robert Watson, World Bank Environmentally and Socially Sustainable Development Network

David J. Tenenbaum

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